New Scientist

WEEKLY April 10–16, 2021

FOCUS ON
CORONAVIRUS

Strong results from first vaccine trial in children

How to bring back mass events safely

Are vaccine passports a good idea?

WHAT ANIMALS ARE REALLY THINKING

Why human-like intelligence is far more common than we thought

THE MARTIAN BIOLOGIST

Meet the woman hunting for signs of life on Mars

PLUS VEGETARIAN DOGS / **FUSION GUNS** / ALIEN GLOBAL WARMING
WHY SYDNEY GETS SO HOT / HOW TO MAKE A PERFECT MARINADE

Science and technology news **www.newscientist.com**

No3329 US$6.99 CAN$9.99

0 72440 30690 5 14

The Mars biologist

Tanja Bosak chooses which rocks NASA's Perseverance rover will prep for a return trip to Earth, where they will be scoured for traces of ancient life. The most surprising outcome would be not finding any, she tells Jonathan O'Callaghan

ROCIO MONTOYA

PERSEVERANCE is the fifth rover that humans have landed on Mars. Its mission is the most exciting yet. While previous rovers have focused on exploring the planet's geology and potential habitability, NASA's latest robotic explorer is actively looking for signs of ancient life. It was an epic moment when Perseverance was lowered to the surface from a hovering sky crane in February.

No wonder the scientists behind it were jubilant. One of those celebrating was geobiologist Tanja Bosak at the Massachusetts Institute of Technology. She has long studied the evidence of Earth's earliest life in our geological record. Now she is bringing that expertise to bear on Mars.

This time, Perseverance is doing the field work for her. The rover is beginning to explore Jezero crater, which was once a Martian lake fed by rivers (see pictures overleaf). It is a fantastic place to hunt for traces of life, with just the right kinds of rocks for preserving fossils, says Bosak.

One of the most interesting aspects of Perseverance's work is choosing a selection of rocks that might contain traces of ancient life and preparing them for a return journey to Earth. The rover carries 43 pristine sample tubes, each of which will be filled and cached under its belly, then left for a subsequent mission to collect and launch back into orbit around Mars. The plan is for these to be picked up and returned to Earth as early as 2031. It is Bosak and her colleagues who have the responsibility of deciding which rocks make the cut.

Funnily enough, she thinks that not finding any traces of life would be the most fascinating outcome. After all, when they were young, the conditions on Mars and Earth were similar. For Bosak, if life never found a foothold on the Red Planet, it would be deeply mysterious.

Jonathan O'Callaghan: How does your work on Earth relate to Mars?

Tanja Bosak: Earth is the only planet where we know life evolved. But the early beginnings of this evolution are pretty murky because there is no good record. Our planet is very geologically active: it has a water cycle so rocks get eroded, buried, covered by other rocks and exposed to high temperatures and pressures. Thanks to that, it's hard to tell what life was like 3 billion years ago or even earlier.

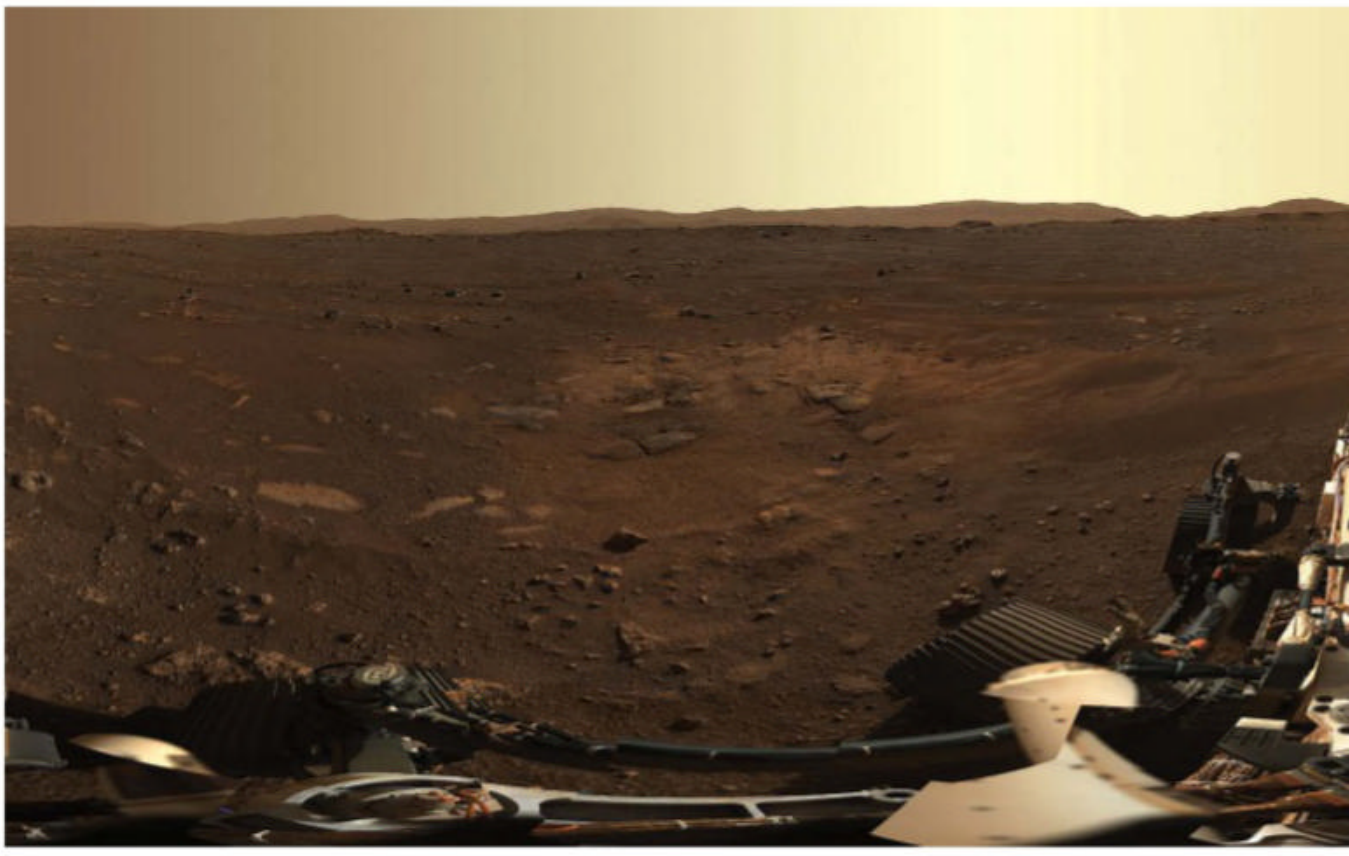
One thing we do have from this period, and which I've studied, are fossilised structures called stromatolites. They are these layered assemblages of many tiny cells and they're the earliest evidence of life on Earth we have.

Getting the chance to ask whether there was also life at this early point on our closest planetary neighbour is something that every biologist longs for. The way we do it is to carry out experimental geobiology on Earth to work out how the signatures of life can be preserved. Then we go and look on Mars for rocks where that kind of preservation could potentially have happened.

What was it like to witness the moment Perseverance landed in February?

Incredible. This is the first space mission that I'm involved in. Just knowing some of the people involved, watching them be nervous and seeing how well everything seemed to go – I was tearing up.

We watched on NASA TV like most people, but we had a meeting organised on the virtual meeting place Gather.town just with team members to chat and rejoice together. ›



NASA/JPL-CALTECH/MSSS/ASU

There does seem to be a lot of excitement about this particular rover. Why do you think that is?
This is the first opportunity for us to get samples from a really well-understood geologic context on Mars. We picked a site that once had water, and now we have a hope of getting samples that we can investigate in all sorts of ways once they are brought back to Earth.

What is Jezero crater like and why was it selected as the landing site?
It is a fairly old crater that is heavily pockmarked and was filled with water at one point in Martian history. We know this because there's a surface feature that looks like a terrestrial river delta. Mars orbiters have shown us that there are various minerals present in the crater that could indicate conditions that were favourable for life.

It's these minerals that got people excited about Jezero. There are minerals called carbonates present that are similar to limestone. The stuff on Mars is magnesium carbonate instead of calcium carbonate. If these minerals were once colonised by microbes, they would have assumed certain telltale shapes that we can look for. There are also fine-grained sediments called mudstones that contain a lot of clay minerals. Microbial fossils or traces of organic matter could be buried and preserved in these sorts of sediments over billions of years.

Your job is to select some of these rocks that will be returned to Earth. Tell us about that.
There is a team of 15 of us. Everyone has expertise in different types of samples. Some people date rocks for a living, others look at the records of ancient magnetic fields, some people have experience with meteorites. We need all that expertise to select a set of samples that can address a lot of questions.

The rover has all sorts of instruments we can use to analyse the composition of the rocks. For example, we can measure the elements that are present, which tells us more about what kinds of rocks we're dealing with. Different rocks serve different purposes – you won't look for life in basalt, because it's an igneous rock and the heat and pressure it has experienced would have eradicated any traces of life. On the other hand, basalts may be an important tool to date the surface.

If we can recognise those telltale shapes related to life left in the carbonate rocks that I mentioned, then those would be great samples to acquire.

These rocks are certainly going to be iconic.
They will be just like the rocks that the Apollo astronauts brought back from the moon. They will be available to the scientific community in the decades to come, so it's important we record our methods carefully. Everyone will need to be able to understand what information went into the selection.

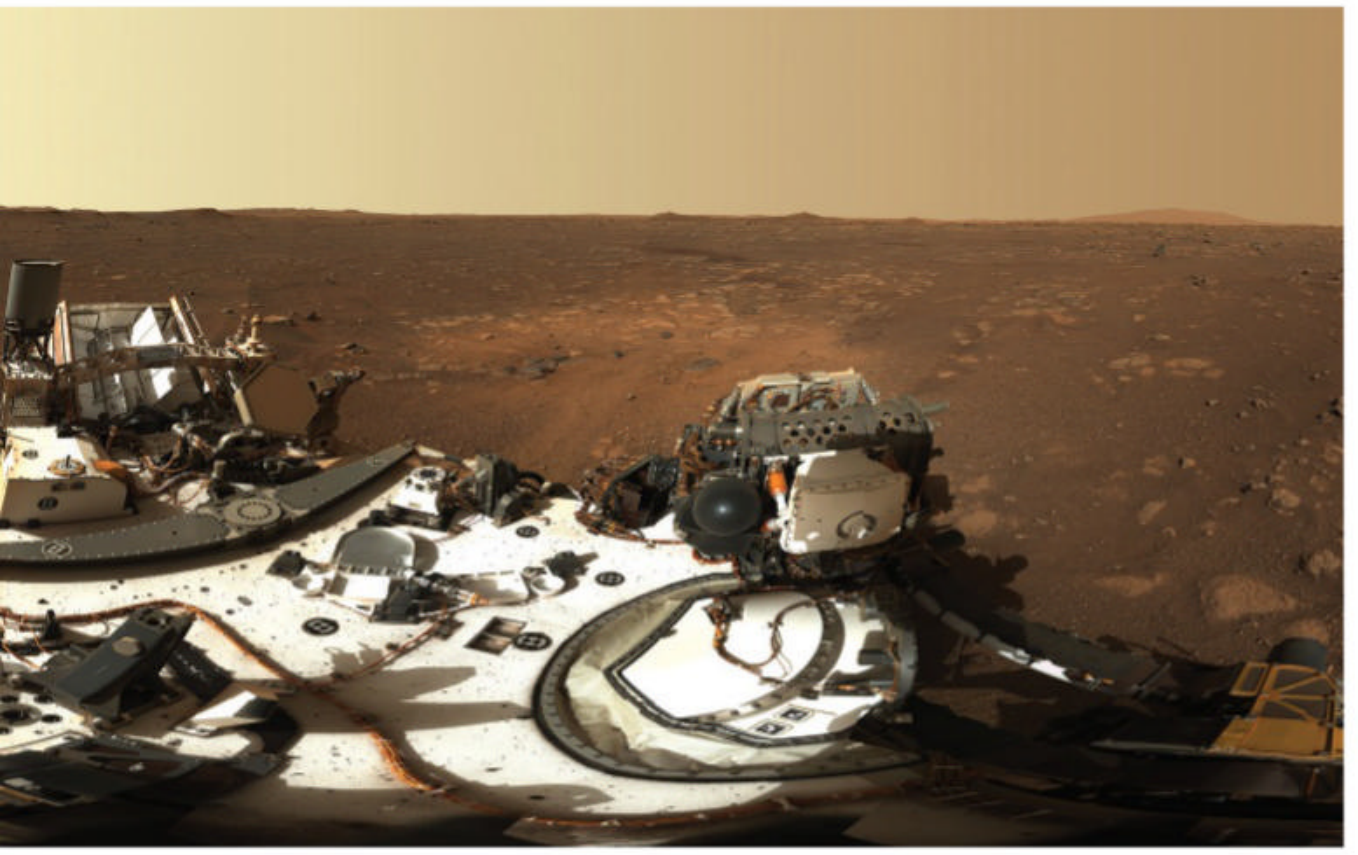
If we do find evidence of past life, what would it look like?
Nothing too obvious like a dried-up bone or a bird feather. It would be microscopic. Given that this terrain is so old, we can't hope for anything non-microbial. And if there was life on Mars, it could not have been huge. We don't have microscopes on the rover, so what we do is look for the best types of rocks and environments that could preserve something interesting. Liquid water is necessary for life – that's condition number one – so this is partly why Jezero was selected as the landing site. Then we have to go to the types of minerals that are the best at preserving potential evidence.

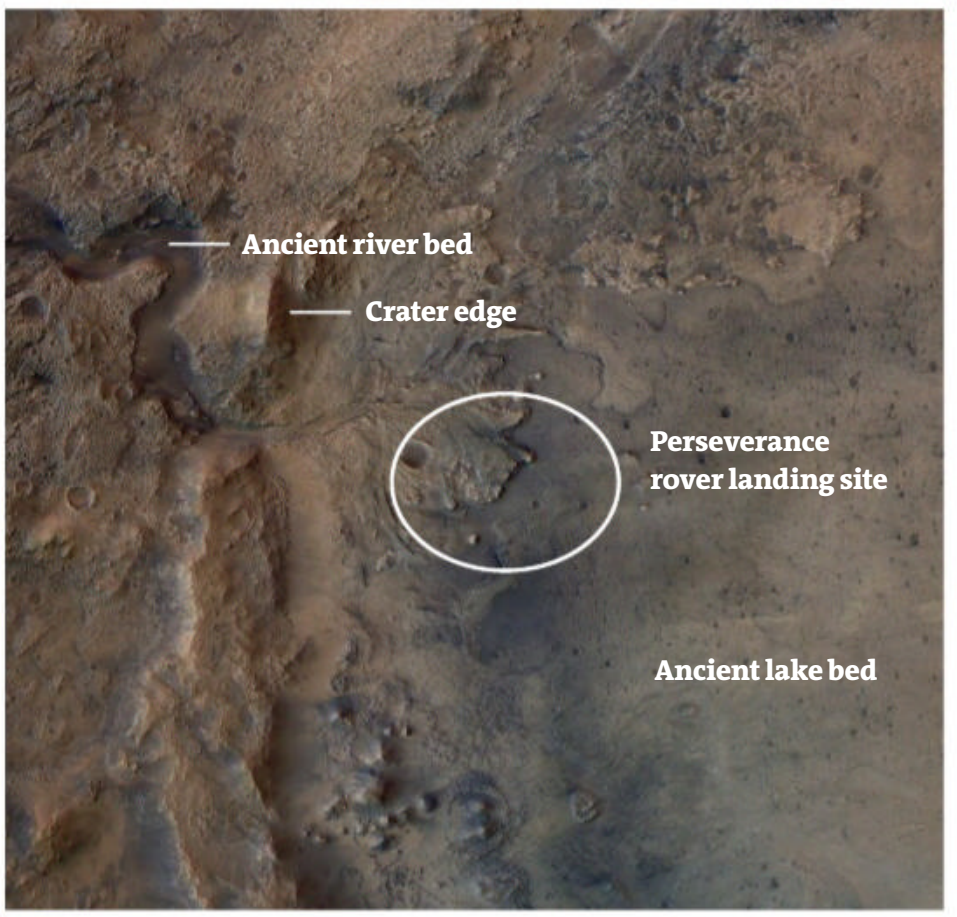
> "Evidence of life on Mars won't be something obvious like a dried-up bone or bird feather"

Might we find a Martian stromatolite?
I would love to see a stromatolite, but I don't think that is necessarily what we'll find. We do know that rocks on Mars could preserve structures equivalent to a stromatolite in principle. But we don't know enough yet about how geology works on the planet to know if that would happen in practice. This is part of the reason for wanting to bring these samples back to Earth. We will need to throw many different tools and analyses at these rocks. Finding life, if there is anything, may be at least a decade into the future.

What would gold-standard evidence for life look like?
The best-case scenario is that we find a sample of a mudstone, analyse it on Earth and find specific types of organic molecules. Or maybe we hit a patch of clay where a fossil is preserved that looks like an organism we would find on Earth. That would tell us that when there was water on Mars, there was life that looked very similar to life on Earth.

Finding something like this could tell us





ESA/DLR/FU-BERLIN

Above: Perseverance is sending back incredible images of Jezero crater

Left: Photography from orbit shows the edges of Jezero crater and an ancient river delta

a lot about the parallel evolution of life. Mars is so close to us, so this would address how different life could be on a nearby planet.

Are you expecting to get a conclusive answer on whether life existed on Mars as a result of Perseverance?
No. Anyone who has looked at fossils on Earth knows that the preservation of fossils or biosignatures is patchy. If we had infinite time and rovers on Mars, we could do a more comprehensive study.

But it's also really exciting to think: what if there was no life? If we see in every single analysis that there's no hint of life on Mars, I think that would be fascinating. I don't expect that to be the case.

Another possibility is that we get some very old samples and see some prebiotic molecules – chemistry that's still learning to become life. To me, that would be even more exciting, because we have no idea of when these sets of molecules learned to be life as we know it, either on Earth or Mars.

Why would finding no evidence of life on Mars be exciting?
It's hard, of course, to demonstrate complete absence of life; you could always argue that maybe we just didn't hit the right outcrop.

But let's say we find nothing even remotely hinting at life. Here we have this lake on Mars, early in its history when we think life was already present on Earth. There was water. There were minerals. If you see absolutely nothing in these conditions even though they are what we think of as habitable, I think that tells us that life needs something more to become widespread.

Beyond Perseverance and its samples, is there more to be done to keep learning about the potential for life on Mars?
There's always another location to go to on Mars. Jezero crater is not the only crater lake on the planet that existed during this time. There are other habitable environments. I think scientists studying Mars after the Perseverance mission will have plenty of choices in the years to come.

If the landing affected you so much, what do you think it will be like when we finally get these Mars samples back to Earth?
In the middle of a pandemic, I think we needed something good to happen, and that's why so many people wanted all the science and engineering that goes into landing a rover on Mars to succeed. As for what will happen when the samples come back – I can't imagine. It's going to be otherworldly. ▮

Jonathan O'Callaghan is a freelance science journalist based in London. You can follow him on Twitter @Astro_Jonny